

four photoconductive organic layers, having an inner pair and an outer pair.

80. (new) The device of claim 79 wherein at least one of said outer pair of said four photoconductive organic layers comprises an organic molecular crystal material.

81. (new) The device of claim 79 wherein at least one of said outer pair of said four photoconductive organic layers comprises a polymeric material.

82. (new) The device of claim 79 wherein at least one of said outer pair of said four photoconductive organic layers comprises a material selected from the group consisting of phthalocyanine compounds, perylene compounds, polyacene compounds, and porphyrin compounds.

83. (new) The device of claim 79 wherein at least one of the two transparent metal substitute electrode layers consists of a conductive oxide.

84. (new) The device of claim 79 wherein at least one of the two transparent metal substitute electrode layers consists of a conductive polymer.

## **REMARKS**

### **Introduction**

Claims 29-35 and 54-84 are now pending in this application. Applicants gratefully acknowledge the Examiner's allowance of claims 31, 35 and 57-63 in the Final Office Action mailed May 10, 2001. This Final Office Action and the references cited therein have been carefully studied and in response, Applicants have amended claim 29 and added new claims 64-84. Applicants have also herein amended the Specification to remedy a typographical error on page 31, line 6. This amendment is supported by the Applicants' original disclosure and does not introduce any new matter into the present application. Reconsideration of the subject patent application in light of the present amendment and

remarks, which have been made to place this application in condition for allowance, is respectfully requested.

**Response to Examiner's Claim Rejections under 35 U.S.C. § 103(a)**

The Examiner has rejected claims 29, 30, 32-34 and 54-56 as being unpatentable over Suzuki et al. in view of Sariciftci et al. under 35 U.S.C. § 103(a). It is respectfully submitted that this rejection should be withdrawn for at least the following reasons.

Independent claim 29 has been amended to claim a stacked configuration of subcells. Claims 30, 32-34 and 54-56 are dependent upon independent claim 29, and thus include this claim limitation as well. Support for the amended claim is summarized on page 15, lines 21-30 of the Specification and further detailed on pages 16-23 of the Specification. Support for the term "subcell" is found on page 19, lines 24-31, and continues on page 20, lines 1-6 of the Specification. Neither Suzuki et al. nor Sariciftci et al. discloses or suggests an organic optoelectronic device that comprises at least two subcells, at least one of which comprises two transparent metal substitute electrode layers. In light of the amendment of claim 29, Applicants respectfully submit that the rejection of independent claim 29, and dependent claims 30, 32-34 and 54-56 under 35 U.S.C. § 103(a) in light of Suzuki et al. and Sariciftci et al. has been overcome and should therefore be withdrawn.

Applicants have also submitted new claims 64-84. These new claims are supported by the Applicants' original disclosure and do not introduce any new matter into the present application. New claims 64-66 are analogous to claims 32-34, but are dependent on allowed claim 31, rather than on the previously rejected claim 29. Similarly, new claims 67-69 are analogous to previously rejected claims 54-56, but are dependent upon allowed claim 31 rather than previously rejected claim 29. New claims 70-72 are dependent upon amended claim 29. New claim 73 is an independent claim, analogous to amended claim 29, but which includes the further limitation of external electrical connections to the subcells. New claims 74-84 are dependent upon new claim 73, and support thereof can be found in the Specification on page 20, lines 8-17.

Applicants respectfully submit that amended claim 29 and new claims 64-84

do not introduce any new matter into the present application, and are in condition for allowance.

Attached hereto is a marked-up version of the changes made to the Specification and claims by the current amendment. The attached page is captioned "**Version with markings to show changes made.**"

In view of the foregoing amendment and remarks, Applicants respectfully submit that all of the pending claims of the subject application are now in condition for allowance. Prompt reconsideration and allowance of the present application are therefore earnestly solicited.

Respectfully submitted,  
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**VERSION WITH MARKINGS TO SHOW CHANGES MADE**

**In the Specification:**

The paragraph starting on page 30 at line 25 has been amended as follows:

--An exemplary embodiment of a organic photosensitive optoelectronic cell with multiple organic layers, or a *multilayer* device 600, is shown in Fig. 6. Insulating or conducting substrate 601 supports the device. First electrode 602 comprises, e.g., ITO of approximate thickness 1000-4000 Å, preferably less than 2000 Å and most preferably around 1000 Å and is adjacent to first organic layer 603 comprising, e.g., PTCDA, PTCBI, or CuPc of approximate thickness 20-50 Å. A second organic layer 604 comprises, e.g., 4,4'-bis[N-(1-naphthyl)-N-phenyl-amino]biphenyl ( $\alpha$ -NPD), approximately 200-500 Å in thickness, and is adjacent to first organic layer 603. A third organic layer 605, comprising, e.g., aluminum *tris*(8-hydroxyquinoline) (Alq<sub>3</sub>), approximately 200-500 Å in thickness, is adjacent to second organic layer 604 to form a rectifying heterojunction at the second organic layer 604 / third organic layer 605 interface. A fourth organic layer 606, comprising, e.g., CuPc, PTCBI, or PTCDA, of approximate thickness 20-50 Å is adjacent to third organic layer 605. Finally, second transparent electrode 607 is adjacent to the ~~third~~ fourth organic layer ~~605~~ 606 and comprises, e.g., ITO of approximate thickness 1000-4000 Å, preferably less than 2000 Å and most preferably around 1000 Å. In this embodiment, an extra pair of organic materials, here second organic layer 604 and third organic layer 605, selected to have appropriate relative mobilities and HOMO-LUMO offset for exciton ionization and charge separation is placed within a "sandwich" of two other organic materials, here first organic layer 602 and fourth organic layer 606. In this instance, the "inner" pair of organic materials, 604 and 605, provides the exciton ionization and charge separation and the "outer" pair, 603 and 606, serves both as charge transporting layers, i.e., transporting the separated carriers to the proper electrodes for substantially ohmic extraction, and as protective cap layers, i.e., protecting the inner pair of organic layers from damage during deposition and use. The outer pair of organic materials may be from the group consisting of CuPc, PTCDA, and PTCBI, or any two of the three may be used. That is, the same material or any combination thereof may be

used for both contacts. Note, however, in embodiment 600, the interior pair of layers, 604 and 605, are preferably deposited so that the cathode side is on top so as to incorporate a low resistance cathode. However, as with the exemplary embodiment of Fig. 4A, the order of the deposition of the inner pair of organic materials is not critical electronically, though the order of the inner pair determines the polarity of the photosensitive optoelectronic device. Since the outer pair of organic layers is relatively thin, their electronic properties are of much less significance here than in the bilayer exemplary embodiment described herein above wherein the CuPc, PTCDA, and PTCBI also performed photoconversion and exciton ionization in addition to transporting the separated carriers. Accordingly, an alternate embodiment of the present invention (not depicted) in a multilayer device would include the cathode on the bottom. The inner pair of organic materials may each be an organic dye chosen to have photosensitivity in a desired region of the spectrum. Since the Alq<sub>3</sub> /  $\alpha$ -NPD pair is photosensitive in the ultraviolet (UV) part of the spectrum, multilayer device 600 with this organic pair combination is a particular exemplary embodiment of a UV photodetector. Further, the dye pair is preferably chosen to have a LUMO-HOMO gap offset as described above. In yet another embodiment (not shown) one or both of the outer pair of organic layers is replaced with a thin layer, approximately 50-150Å of Mg:Ag alloy which acts as a charge transfer, extraction, and protective cap layer.--

#### **In the Claims:**

Claim 29 has been amended as follows:

29. (thrice amended) An organic photosensitive optoelectronic device comprising:  
a substrate having a first major surface and a second major surface; and  
at least two subcells in superposed relationship upon said first major surface  
of said substrate;  
wherein at least one of said subcells comprises:  
two transparent metal substitute electrode layers in superposed  
relationship upon said first major surface of said substrate; and

four photoconductive organic layers, having an inner pair and an outer pair, disposed between said two transparent metal substitute electrode layers.

Claims 64-84 have been added as follows:

64. (new) The device of claim 31 wherein at least one of said outer pair of said four photoconductive organic layers comprises an organic molecular crystal material.

65. (new) The device of claim 31 wherein at least one of said outer pair of said four photoconductive organic layers comprises a polymeric material.

66. (new) The device of claim 31 wherein at least one of said outer pair of said four photoconductive organic layers comprises a material selected from the group consisting of phthalocyanine compounds, perylene compounds, polyacene compounds, and porphyrin compounds.

67. (new) The device of claim 31 wherein at least one of the two transparent metal substitute electrode layers consists of a conductive oxide.

68. (new) The device of claim 67 wherein the conductive oxide is selected from the group consisting of indium tin oxide, tin oxide, gallium indium oxide, zinc oxide and zinc indium oxide.

69. (new) The device of claim 31 wherein at least one of the two transparent metal substitute electrode layers consists of a conductive polymer.

70. (new) The device of claim 29 wherein the at least two subcells have external electrical connections.

71. (new) The device of claim 70 wherein the at least two subcells are electrically connected

in parallel.

72. (new) The device of claim 29 wherein each of the at least two subcells comprises:

two transparent metal substitute electrode layers in superposed relationship upon said first major surface of said substrate; and

four photoconductive organic layers, having an inner pair and an outer pair, disposed between said two transparent metal substitute electrode layers.

73. (new) An organic photosensitive optoelectronic device comprising:

a substrate having a first major surface and a second major surface; and  
at least two subcells in superposed relationship upon said first major surface of said substrate;

wherein each of the at least two subcells has external electrical connections;  
and

wherein at least one of said subcells comprises:  
two transparent metal substitute electrode layers in superposed relationship upon said first major surface of said substrate; and  
at least one photoconductive organic layer disposed between said two transparent metal substitute electrode layers.

74. (new) The device of claim 73 wherein the at least two subcells are electrically connected in parallel.

75. (new) The device of claim 74 wherein each of the at least two subcells comprises:

two transparent metal substitute electrode layers in superposed relationship upon said first major surface of said substrate; and

at least one photoconductive organic layer disposed between said two transparent metal substitute electrode layers.

76. (new) The device of claim 75 wherein the thickness of each of the at least two subcells is

optimized for maximum internal quantum efficiency and the total number of said subcells comprised in the organic photosensitive optoelectronic device is limited by that which produces no further increase in the external quantum efficiency.

77. (new) The device of claim 73 wherein at least one of the two transparent metal substitute electrode layers consists of a conductive oxide.

78. (new) The device of claim 73 wherein at least one of the two transparent metal substitute electrode layers consists of a conductive polymer.

79. (new) The device of claim 73 wherein the at least one photoconductive organic layer is four photoconductive organic layers, having an inner pair and an outer pair.

80. (new) The device of claim 79 wherein at least one of said outer pair of said four photoconductive organic layers comprises an organic molecular crystal material.

81. (new) The device of claim 79 wherein at least one of said outer pair of said four photoconductive organic layers comprises a polymeric material.

82. (new) The device of claim 79 wherein at least one of said outer pair of said four photoconductive organic layers comprises a material selected from the group consisting of phthalocyanine compounds, perylene compounds, polyacene compounds, and porphyrin compounds.

83. (new) The device of claim 79 wherein at least one of the two transparent metal substitute electrode layers consists of a conductive oxide.

84. (new) The device of claim 79 wherein at least one of the two transparent metal substitute electrode layers consists of a conductive polymer.